Do we need to perform bilateral hip bone mineral density examination?

Annisa Layalia Widjanarko,[1] Rachmat Gunadi Wachjudi,[2] Muhammad Rizal Chaidir[3]

[1] Faculty of Medicine,
[2] Department of Internal Medicine,
[3] Department of Orthopaedy and Traumatology,
Universitas Padjadjaran/ Dr. Hasan Sadikin General Hospital, Bandung, Indonesia

Corespondence:
Annisa Layalia Widjanarko
Jalan Raya Bandung-Sumedang Km. 21, Sumedang, Jawa Barat, Indonesia
E-mail: annisa.layalia@yahoo.com

Abstract

Background: Bone mineral density (BMD) measurement is one of the method for making osteoporosis diagnosis. World Health Organization (WHO) recommends the measurement of BMD conducted at antero-posterior lumbar vertebrae, unilateral hip (femur), and radius. However, there was a concern about osteoporosis under diagnosis if the measurement is only conducted at unilateral hip. Some studies found significant differences of BMD between both femur and evidence of the importance to examine both femur in making the diagnosis of osteoporosis. This study aims to determine anydifference between right and left femur BMD measurement and to investigate the bone status result with measurement of BMD of bilateral femur in Hasan Sadikin General Hospital.

Methods: A retrospective study was conducted from June to November 2015. Patients who received dual-femur BMD testing using General Electrics (GE) Lunar Prodigy dual-energy x-ray absorptiometry at the DXA Facility in Hasan Sadikin General Hospital, Bandung between January 1, 2006 to December 31, 2014 were included. Statistical analysis performed to assess the difference and the correlation between the BMD of two femurs (g/cm^2). T-scores of the subject were implemented into bone status according to WHO Diagnostic Criteria for Osteoporosis.

Results: From sixty-one patients included in this study, there were difference bone status resulted from BMD of the femoral neck, Ward's triangle, trochanter, and total hip area between right and left femur, although no statistically significance were found. There was a positive correlation between BMD of right and left femur at all areas of femur. There were 16 subjects (26.1%) showed combination level of bone status (normal, osteopenia, or osteoporosis in one femur).

Conclusion: BMD results in each area of the right and left femurs are different.Therefore, performing bilateral hip BMD examination as a routine measurement for makingdiagnosis of osteoporosis is important.

Keywords: Bone Mineral Density, Dual-energy X-ray Absorptiometry, Femur, Osteoporosis

Background

Osteoporosis is a metabolic disease characterized by low bone mass and deterioration of bone microarchitecture, which can lead to fractures. Based on2013 International Osteoporosis Foundation (IOF) report, the prevalence of osteoporosis in Indonesian is 23% in women aged 50-80 years old, and 53% in women aged 70-80 years old. It is also stated that by 2050 there will be an increase of 135% of osteoporosis prevalence in adult Indonesian over 50 years of age population, and an increase of one-third prevalence of high-risk osteoporosis population.[1] Therefore, it is important to prevent, diagnose, and giving appropiate intervention before the complications occured. The diagnosis of osteoporosis should be made comprehensively, includes: the assessment of history, risk factors, and determination of 10-year fracture probability using FRAX tool; physical examination; bone mineral density (BMD) testing and vertebral imaging. Based on a World Health Organization (WHO) technical report, the National Osteoporosis Foundation (NOF) stated that quantitative measurement of bone mineral content can be achieved by dual-energy X-ray absorptiometry (DXA), at three regions of interest; antero-posterior lumbar vertebrae, femur, and radius. Bone mineral density measurement at the femur is the best predictor of risk for future hip fracture.[2]

In 1994, WHO stated that BMD measurement at unilateral femur was the reasonable and deemed reliable technology available for bone density analysis at the time. Since then, most of BMD measurements are conducted unilaterally, including at Dr. Hasan Sadikin General Hospital Bandung. This action is also supported by the International Society for Bone Densitometry (ISCD), who stated that the measurement can be done at either hip, and the diagnosis is made based on the lowest T-score.[3] However, unilateral measurement does not rule out the diagnosis of osteoporosis on the contralateral hip, especially when spine status is normal.

Some studies have analyzed whether dual-femur examination had clinical importance in establishing the diagnosis of osteoporosis. In 2012, Hwang et al., found 30% rate of T-score discordance between hips, which lead to the underestimation of osteoporosis if only unilateral hip examination was conducted.[4] This is supported by Mounach, et al.(2012) study which determine the prevalence of significant BMD difference between right and left hip and how it influences the classification of bone status. They discovered that the discordance

frequency between both hip increases with age, and thus support the need for bilateral femur BMD measurement.[5]

Some clinicians at Hasan Sadikin General Hospital Bandung have ordered dual hip BMD measurement for the diagnosis of osteoporosis. Questions arise about the importance of conducting bilateral hip measurement in diagnosing osteoporosis. Therefore, there may be a possible difference between BMD of both femurs that can affect bone status. However, to the best of our knowledge there has not been any published article regarding the difference of right and left femur BMD in Bandung. This study aims to determine the presence of difference of BMD between both femurs, investigate the resulting bone status produced by bilateral femur BMD measurement, and evaluate whether it is of clinical importance.

Methods

A retrospective study was conducted in June until November 2015. The population of this study was all patients who received dual-femur BMD testing using General Electrics (GE) Lunar Prodigy dual-energy x-ray absorptiometry at the DXA Facility in Hasan Sadikin General Hospital Bandung. Sample calculation used the equation for numerical analysis with paired data with 95% confidence interval, resulting in 161 subjects for each right and left femur group. Sample were included from data of patients who came between January 1, 2006 and December 31, 2014, and excluded patients whose variables of interest were not recorded. Data collected, include: BMD of both femur which is expressed as grams per centimeter square (g/cm^2), patient's age and sex, and osteoporosis risk factors, such as BMI category, elderly status, and menopausal status for women.There were only 61 patients who had undertaken dual-femur testing with all variables recorded, thus included as subject.

The data were analyzed using Microsoft Excel 2010 for Windows and Statistical Package for the Social Sciences (SPSS) version 17. The BMD result of the right and left femur were compared using the Wilcoxon signed rank test ($P<0.05$). The correlation between right and left femur BMD was determined using Spearman's test. Each BMD was compared to the normal young adults of the same age (T-score) and was implemented into bone status according to WHO Diagnostic Criteria for Osteoporosis (Normal >-1.0, Osteopenia -1.0 to -2.5, Osteoporosis ≤-2.5).[2] Chi-square was conducted to establish the association between the bone status of right and left femur. The results were categorized into Normal-normal, Osteopenia-osteopenia, osteoporosis-osteoporosis, and combination (normal-osteopenia, normal-osteoporosis, osteopenia-normal, osteopenia-osteoporosis, osteopenia-osteoporosis and osteoporosis-normal at one hip). The results were presented in the form of tables and figures as appropriate. Ethical clearance for this study was obtained from Health Research Ethical Committee Hasan Sadikin General Hospital (No. LB.04.01/A05/EC/231/VII/2015).

Results

Sixty-one subjects met the inclusion and exclusion criteria, used as sample in this study. The subject characteristics are presented in Table 1. Subjects was dominated by female (86,9%). Fifty-two of fifty-three female subjects had menopause. Subjects' age varied from 48 to 88 years old, with the median age 67-year-old. There were 34 subjects (55.74%) that were included in the normal BMI category. Forty-one of the subjects (61.27%) were elderly.

Table 1 Characteristic of Subjects in Dual Femur DXA Measurement

Characteristic	Result
Sex	
Female N(%)	53 (86.9)
Male N(%)	8 (13.1)
Age Median (Range)	67 (48-88)
Elderly (above 60 year-old)	
Yes N(%)	41 (61.27)
No N(%)	20 (32.79)
BMI Category	
Underweight N(%)	3 (4.92)
Normal N(%)	34 (55.74)
Overweight N(%)	18 (29.50)
Obese N(%)	6 (9.84)
Menopause (in female) n=53	
Yes N(%)	52(98.11)
No N(%)	1(1.89)

There was a positive correlation between right and left femur BMD at the femoral neck, Ward's triangle, trochanter, and total hip area (r=0.881, p=0.00; r=0.791, p=0.00; r=0.736, p=0.00; and r=0.815, p=0.00, respectively). The bilateral BMD results were compared. According to the Wilcoxon signed ranks test ($P<0.05$), there was no significant difference between right and left femur BMD at every area. This can be seen in table 2.

Table 2 Associations of Right and Left Femur BMD at Each Subregion

Area	Right Femur Median (Range) N=61	Left Femur Median (Range) N=61	P value
Trochanter	0.633 (0.230-1.091)	0.641 (0.411-1.115)	0.151
Femoral Neck	0.798 (0.370-1.319)	0.756 (0.400-1.354)	0.926
Ward's Triangle	0.614 (0.300-0.892)	0.607 (0.385-1.039)	0.918
Total Hip	0.838 (0.377-1.120)	0.847 (0.448-1.248)	0.189

Bone status of both femurs was obtained from the area with the lowest T-score. The association between the bone status from right and left femur was determined using Chi-square test. Combination of bone status within right and left femur was found in total 16 subjects (26,1%), as followed: 1 subject (1.6%) with normal-osteopenia bone, 1 subject(1.6%) with normal-osteoporosis, 5 subjects(8.2%) with osteopenia-normal, 6subjects (9.8%) with osteopenia-osteoporosis, and 3subjects (4.9%) with osteoporosis-osteopenia. The

association between right and left femur bone statuscan be seen in table 3.

Table 3 Association between Bone Status of Right and Left Femur BMD

Left Femur Status	Right Femur Status			Total
	Normal	Osteopenia	Osteoporosis	
Normal	8 (13.1)	5 (8.2)	0 (0)	13 (21.3)
Osteopenia	1 (1.6)	10 (32.8)	3 (4.9)	24 (39.3)
Osteoporosis	1 (1.6)	6 (9.8)	17 (27.9)	24 (39.3)
Total	10 (16.4)	31 (50.8)	20 (32.8)	61 (100)

Discussion

Controversies regarding bilateral femur BMD scanning is still an ongoing issue. The diagnosis of osteoporosis is established based on the lowest T-score at the spine or femur, in a unilateral femur scanning.[2] However, unilateral femur measurement does not rule out the diagnosis of osteoporosis on the contralateral hip, especially when there is a significant difference between the left and right femur BMD.

In this study, there were differences between right and left femur BMD at every area (table 2), although none was statistically significant ($P > 0.05$). The median BMDs (g/cm^2) between right and left femurs were as follows: trochanter 0.633 versus 0.641, femoral neck 0.798 versus 0.756, Ward's triangle 0.614 versus 0.607, and total hip 0.838 versus 0.847. The result was constantly with Hwang, et al. study, who also found the different BMD result of the right and left femur in femoral neck and trochanter area over Korean women with age more than50 years old.[4] However, in their study,the BMD difference in the neck and trochanter area is statistically significance. Within our study, we also found that the Ward's triangle had the smallest median BMD between all areas because of its trabecular structure. As it may produce a false-positive result, the Ward's triangle examination should not be used in making the diagnosis of osteoporosis.[5]

Current study found a strong positive correlation between right and left femur BMD at all areas. The correlation means that the high value of right femur BMD will relate with thehigh value of left femur BMD. This positive correlation might be caused by small absolute differences between the right and left femur, as shown by table 2. Mounach, et al. also found that bilateral femur BMD measurement may be useful in clinical setting. They found strong correlations between right and left BMD at the femoral neck, trochanter, and total hip area.[6] These differences can be caused by genetic variation, immobilization of one limb, and stroke causing hemiplegia.[7,8,9] The difference may also be caused by lack of weight-bearing activity or gait abnormality, associated with a pathologic disease,such as foot or knee pain.[10]

In clinical practice, the bone status for each subject was determined from the area with the lowest T-score. Cross-tabulation was done to see the relationships between right and left bone status. Although the difference of left and right femur BMD was not statistically significant, we found 16 (26.1%) subjects who had combination bone status (table 3). Three of them (4.9%) had osteoporotic bone status in the right femur but osteopenic in the left femur, and 6 subjects (9.8%) had osteopenic bone status in the left femur but osteoporotic in the right femur. This means, if the BMD measurement was only conducted on one-left-femur, there would be 4,9% subjects underdiagnosed as osteopenia, whereas the osteoporotic status ofthe contralateral femur was not found. Thus, the bilateral femur BMD measurement is more benefit than unilateral measurement. In Hwang *et al*. study, bilateral hip measurementalso found useful to prevent underestimation of osteoporosis, as they found 15 (3.9%) of their 384 subjects who had osteopenia but were only diagnosed as normal bone density by unilateral femur BMD measurement.[4]

A study conducted by Hamdy, et al., in 2006 found that there were 16% subjects who had osteoporotic bone status only in the left femur, and 10% subjects whohad osteoporotic bone status only in the right femur.[8] This study is similar to our study in which these patients could benefit from bilateral femur BMD measurement. In this study, the diagnosis was established regardless of the vertebral status to see the difference between right and left femurs. However, there are some studies who determine the vertebral status as normal or osteopenic before establishing the osteoporosis diagnosis at the femurs. The femoral statuses were assumed as osteoporosis if the vertebral status was already osteoporosis.[6, 8]

Some studies compared the T-score values between bilateral and unilateral hip measurements. Cole and Larson found that a bilateral hip BMD measurement led to a change of diagnosis classification to a more severe categories in 9% subjects.[9] In another study, Cole,et al. reported 3.3% population in their study whose diagnosis changed from osteopenia into osteoporosis.[11]It suggests that the difference BMD result between both femurs canbe large enough to change the classification of bone status, if bilateral femurs examination are performed.

Bilateral hip measurement is doable to perform bilateral hip measurement in every suspected osteoporosis cases, as the scanning time became faster with the recent technologies. In Korea, the cost is also no longer an issue.[4,6] However, in Indonesia, the Indonesia National Health Insurance, BPJS, only covers a routine BMD examination, such aslumbar, single hip, and radial area. When a clinician ordered bilateral hip measurement, the patient should pay on themselves. Therefore, the financial issue should be considered before ordering bilateral hip BMD examination.

There were a few limitations of this study. We use aretrospective method study with secondary data as oursubjects. As bilateral femur BMD measurement is not a standard procedure in Dr. Hasan Sadikin General Hospital, there waslimited amount of patients who undertook dual-femur testing. Therefore, the number of samples did not meet the minimum amount of sample and could not be extrapolated to the general population. A prospective cohort would describe the current population better, and further analysis of bilateral BMD testing in all age group should be performed. Besides, our study haven't involve the spine status as predictive value for osteoporosis in each subject. Further analysis about diagnosis value of the spine status for osteoporosis should be performed. This study also have not investigated the influence

of individual's side dominance to the BMD level ofthe right and left femur. So, further studies should be conducted to see whether hip dominance plays a role in the right and left BMD measurement, and thus provide a more interesting issue.

Conclusion

In conclusion, there were different level of BMDat every area of right and left femurs, but none was statistically significant. There were strong positive correlations of bone status and BMD levelamongall areas in the right and left femur.There were 26.1%population who had combination bone status based on T-score resulted from the BMD of right and left femur BMD. Bilateral femur BMD measurement might be useful in a clinical setting where the patient experiences lack of weight-bearing. The cost issue needs to be considered. Since it is not a routine measurement for osteoporosis diagnosis, before ordering bilateral hip BMD, the clinicians should review how importance is the assesment.

References

1. International Osteoporosis Foundation. Asia Pacific Audit Indonesia. Hong Kong: International Osteoporosis Foundation; 2013.
2. National Osteoporosis Foundation. Clinician's guide to prevention and treatment of osteoporosis. Washington, DC: National Osteoporosis Foundation; 2010.
3. Schousboe JT, Shepherd JA, Bilezikian JP, Baim S. Executive summary of the 2013 ISCD Position Development Conference on bone densitometry. JCD. 2013;16(4):455-467.
4. Hwang JH, Park SY, Lee SH, Han SB, Ro KH. Differences in bone mineral density between the right and left hips in postmenopausal women. J Korean Med Sci. 2012;27:689-690.
5. El Maghraoui A, Roux C. DXA scanning in clinical practice. QJM. 2008;101(8):605-17.
6. Mounach A, Abayi DA, Ghazi M, Ghozlani I, Nouijai A, Achemlal L, *et al.* Prevalence and risk factors of discordance between left- and right-hip bone mineral density using DXA. ISRN Rheumatology. 2012;108(6):289-295.
7. Myint PK, Poole KES, Warburton EA. Hip fractures after stroke and their prevention. QJM. 2007;100(9):539-545.
8. Hamdy R, Kiebzak GM, Seier E, Watts NB. The prevalence of significant left-right differences in hip bone mineral density. OSTEOPOROSIS INT. 2006;17(12):1772-1780.
9. Cole RE. Larson J. The effect of measurement of the contralateral hip if the spine is not included in the bone mineral density analysis. Journal of Clinical Densitometry. 2006;9(2):210-216.
10. Seeman E, Delmas PD. Bone quality—the material and structural basis of bone strength and fragility. N ENGL J MED. 2006;354(21):2250-61.
11. Cole RE. Improving clinical decisions for women at risk of osteoporosis: dual-femur bone mineral density testing. J AM OSTEOPATH ASSOC. 2008;108(6):289-95.